RESEARCHES

ON

THE INTIMATE STRUCTURE OF THE BRAIN,

HUMAN AND COMPARATIVE.

FIRST SERIES.

ON THE STRUCTURE OF THE MEDULLA OBLONGATA.

BY

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XIV. *Researches on the Intimate Structure of the Brain, Human and Comparative.*— First Series. *On the Structure of the* Medulla oblongata. *By* J. LOCKHART CLARKE, *Esq., F.R.S.*

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(1.) GALEN believed that the *medulla spinalis* commences as high up as the lower border of the *pons Varolii*. This, like nearly every other, opinion of the Greek anatomist was adopted by all his successors until the time of SYLVIUS and VESALIUS. SYLVIUS traced the origin of the spinal chord from the whole base of the brain[1]; VESALIUS, only from the *corpora quadrigemina*[2]. COLUMBUS[3], VAROLIUS[4], SPIGELIUS[5], LAURENTIUS[6], RIOLANUS[7], HIGHMORE[8], described it as arising by two roots,—one large, from the entire base of the brain; the other small, from the cerebellum. But PICCOLHOMINI introduced a better description of these parts, by restricting the term "medulla *spinalis*" to the contents of the spinal column; while to the whole *intra-cranial* prolongation along the base of the brain, he applied the term "medulla *oblongata*"[9], which has been retained to the present day, though many anatomists have differed with regard to the number of parts it has been supposed to comprehend. According to WILLIS[10], it includes the *whole base* of the brain, from the *corpora striata*—which he called "medullæ oblongatæ apices"—to the *foramen magnum*. The same view was adopted by VIEUSSENS[11], WINSLOW[12], and others; while ROLANDO[13] employed the term in a more restricted sense; and RIDLEY[14], who did the same, substituted for it the term "isthmus," and CHAUSSIER[15] that of "mesocephale," which included the *pons*, *tubercula quadrigemina*, with the *superior peduncles of the cerebellum*, and not the pons *only*, as sometimes stated. FLOURENS[16], again, on the ground of his experimental inquiries,—which led him to conclude that the seat of *excitability* begins or ends with the *corpora quadrigemina*,—limits the *medulla oblongata* between these bodies and the eighth pair of nerves. In this country the

[1] Isagoge (1556), lib. iii. cap. xxii.

[2] De Humani corporis Fabricâ, lib. iv. and vii.

[3] De Re Anatomica, p. 367 (1562).

[4] De Nervis Opticis, p. 128.

[5] De Humani Corporis Fabricâ, p. 295 (1627).

[6] Historia Anatomica, p. 529 (1600).

[7] Anthropographia, lib. v. (1618).

[8] Corp. Hum. Disquisit. Anat. lib. i. (1651).

[9] Anatomicæ Prælectiones, lib. 5. Lect. iii. and v. (1586). The whole of the description is excellent, and very superior to that of any previous anatomist.

[10] Cerebri Anatome, cap. ii. (1664).

[11] Neurographia Universalis (1684).

[12] Exposition Anatomique, Traité de la Teste, p. 126 (1695).

[13] Recherches Anatomiques sur la Moëlle allongée.

[14] Anatomy of the Brain, p. 126 (1695).

[15] De l'Encéphale, p. 106.

[16] Recherches Expérimentales sur les Propriétés et les Fonctions du Système Nerveux, pp. 21 and 239.

medulla oblongata is generally understood to extend from near the points of the *anterior pyramids* to the lower border of the *pons*, and as such it is described in this memoir.

(2.) It is well known that in the *spinal chord* the columns of white and grey substance are parallel to each other, and preserve the same relative position throughout their entire course; but in the *medulla oblongata* these parts not only assume a different arrangement, by becoming more or less blended with each other and with new structures, but frequently pursue a curvilinear direction in different planes inclined at varying angles. It is evident, therefore, that transverse and longitudinal sections, however transparent they may be made, must be insufficient, when employed alone, to complete the examination of so intricate a structure. For this reason, after having made myself thoroughly acquainted with the microscopical anatomy of these parts, and traced their relations and connexions, as far as possible, by my own method of preparation, which I find superior to any other that I have seen of the same kind, I then employed, in conjunction with it, the method of REIL; so that when necessary, the structure revealed at different stages of the dissection was compared with transparent sections through the same parts. Great assistance was also obtained by making, simply for my own use, as I dissected through the depth of a part, a multitude of sketches, which were placed side by side and carefully examined in succession: the plan is tedious and demands patience, but can be confidently recommended to anatomists as a valuable expedient for ascertaining the arrangements of a complicated and intricate structure of which the parts are so continually changing their course and relative position, in varying planes, that in the dissection each must necessarily be destroyed whilst seeking its relation to others*.

Medulla oblongata.

(3.) Anatomists are aware that the *medulla spinalis* consists externally of longitudinal white fibres, but internally of grey substance; and that the latter communicates with the surface by means of the posterior-lateral sulcus which divides the white substance of each lateral half into a posterior and an antero-lateral column. Through this sulcus or fissure, a few of the roots of the spinal nerves are connected with the central grey portion, while the rest reach it through the posterior white columns, to which, therefore, they are exclusively attached, as I first pointed out in a former communication to the Royal Society†. In the medulla oblongata, a considerable difference exists in the arrangement and relative position of the white and grey columns, and new structures are superadded. Fig. 5, Plate XII. represents the posterior aspect of the human medulla oblongata, and fig. 6 a side view of the same, enlarged. On each side of the anterior median sulcus is the *corpus pyramidale anterius* (*i i*, figs. 6 and 9). Adjoining this, along its outer border, we find the *olivary column* (*h*, fig. 6), which contains or encloses the *corpus olivare*, and is separated by the lateral column (*g*) and by the *posterior*

* In the method I formerly employed, I have succeeded in making very great improvements, which will be explained on some future occasion.

† Philosophical Transactions, 1851. Part II.

grey cornu or *column* (*f*) from the *corpus restiforme* (*a*). At the commencement of the fourth ventricle, the *corpora restiformia* (*a*, figs. 5 and 6) diverge to form its lateral boundaries; and between them and the posterior median sulcus, they enclose the posterior pyramids, or *corpora pyramidalia posteriora* (*bb*), which diverge in a similar manner at the point of the calamus scriptorius.

(4.) At the lower part of the medulla oblongata, the *gelatinous substance*, or extremity of the posterior cornu, reaches the surface, and enlarging as it ascends, forms a prominent column (fig. 6 *f*, Plate XII.), which near the olivary body becomes overlaid and concealed by a new system of transverse *arciform* fibres. This grey column, which was first described and called by ROLANDO the *tuberculo cinereo—tubercule cendrée*,—is generally believed to appear on the surface of the human medulla only; but this opinion is erroneous, for I have found it comparatively larger, or at least more prominent, in some Mammalia, as the Cat, in which its upper part, where the *arciform* fibres commence, presents a well-marked and rounded head or projection. The anterior (or as seen in fig. 6, the lower) border of the *tuberculo cinereo* rests on the lateral column which separates it from that which encloses the olivary body.

(5.) *Of the Arciform Fibres.*—The fibres so named appear in part on the lateral surfaces of the medulla, and have been somewhat differently described by SANTORINI, MALACARNE, ROLANDO, ROSENTHAL, SOLLY, and JOHN REID. In Man they vary considerably in distinctness, and sometimes apparently in arrangement; but in a great number of specimens which I carefully examined, their general course in each was found to be alike. Those on the right side of the human medulla are represented in fig. 6 *. These arciform fibres may be divided into two layers—*superficial* and *deep*. The *deep* layer will be described further on, as part of the upper region of the medulla. The *superficial* layer, for convenience of description, may in turn be divided into two sets. The *first* set are entirely transverse in their course, and appear externally as an arched and flattened band extending round each side of the medulla from the anterior sulcus to the posterior columns, especially the restiform body, through which they interlace in a very intricate manner (see fig. 36, Plate XVII. x'); but if this band, in a properly-prepared transverse section, be examined with a sufficient magnifying-power, it may be seen to be partly formed by the convexities of many subordinate series of arcs, of many sizes, and proceeding from different depths and regions of the medulla. In three situations these are most numerous and conspicuous. One series issue from the substance of the anterior pyramid, particularly from its posterior portion, where a vesicular network or plexus and small groups of cells are developed, and whence a kind of radiation may be observed (see fig. 36, Plate XVII.): the next series issue also from the back of the pyramid, and turn round the surface of the olivary body to the lateral column, where they join the

* It may be proper to state, that in any single medulla they are seldom seen so distinctly as they are represented in this figure, which was drawn from picked and well-marked specimens that had been macerated for some hours in spirit and then treated with a mixture of spirit and acetic acid, after the membranes were removed.

deep layer in a plexus which contains a peculiar group of cells, to be described further on (see figs. 30 to 32, and fig. 36): the third series are continued backwards from the same plexus and from the front of the *tuberculo cinereo*, around the surface of which they turn to spread out and interlace with the fibres of the posterior columns (same figs.); but while crossing the *tuberculo cinereo*, which they entirely overlay, a few turn off and take a downward course along its surface, as represented in fig. 6, Plate XII. *f*. When this first set or band of arciform fibres (A′, fig. 36, Plate XVII.) are traced round the surface of the pyramid towards the bottom of the anterior sulcus, they are found to embrace closely the *side* of the pyramid, where in the upper part of the medulla is developed a layer of cells from which some take their origin (A). Passing backwards in a slightly oblique or ascending direction, they may be seen in a good transverse section, made in a corresponding plane, to have the following destinations:—some, as already stated, sweep round and *into* the back of the anterior pyramid, amongst the vesicular groups or plexus located there; some pass deeply backwards to the lateral and posterior columns of the same side; others cross obliquely to those of the opposite side, decussating through the *raphè* with fibres from the opposite band (B, fig. 36); *below* the olivary bodies, these latter fibres are not numerous; for those that proceed from the posterior and lateral columns to decussate through the now commencing *raphè*, run for the most part into the *substance* of the opposite pyramid, and but sparingly round its periphery; but in the *upper* part of the medulla, as will be shown further on, they are exceedingly abundant behind the anterior sulcus (see fig. 36). The remaining fibres of the arciform band, on reaching the bottom of the sulcus, return in a series of loops to be continuous with the band that embraces the opposite pyramid (fig. 36).

(6.) The *second* set of superficial fibres proceed from the substance of the anterior pyramid, nearer the lower border of the *pons Varolii* (fig. 6 J, Plate XII.). Curving downwards and backwards, they sweep over and around the lower end of the olivary body to re-ascend obliquely with the first set to the upper extremity of the restiform column. These fibres are sometimes very numerous, and often appear like a distinct fasciculus of the pyramid. As the *former* set were traced from the bottom of the anterior sulcus to the *central* and *posterior parts* of the medulla, it is probable that these have similar connexions with corresponding portions of the *pons*. Although, for the sake of clearness and facility of comprehension, this arciform system of fibres has been divided into separate layers, it may be well to observe, that there is no distinct line of separation between them, and that they all intermingle and communicate in an intricate manner.

(7.) In most of the Mammalia the arciform fibres are very conspicuous, but less intricate in their arrangement than those of the human medulla. As in Man, they are connected with the anterior pyramid and olivary body, as well as with the lateral column, and ascend obliquely backwards, in a broad quadrilateral band, to the posterior pyramids and restiform columns. Fig. 7, Plate XII. represents their arrangement in the Sheep. In the Cheetah or hunting Leopard (fig. 9), they appear to cover nearly the

whole of the medulla on each side, and to be developed in a remarkable degree. In birds, reptiles and fishes they may be seen without difficulty.

Of the Corpora Pyramidalia Anteriora.

(8.) *External appearance.*—The anterior pyramidal columns were first pointed out in the plates of EUSTACHIUS towards the end of the sixteenth century, and were so named by WILLIS, who considered them as the channels by which the animal spirits were conveyed from the cerebellum to the par vagum and contiguous nerves*. In Man, as is well known, they are largely developed, and appear at the lower border of the *pons* as two thick and rounded cords, which flatten as they descend to meet each other at a point. They are also of considerable but variable size in all the Mammalia, and in some of the larger beasts of prey, as the *Lion*, *Hyæna* and *Jaguar*, I have found their external dimensions to be nearly, if not quite, equal to those of Man; but in depth they are mostly smaller among this class of animals. Well marked, prominent and rounded in the *Quadrumana*,—at least in the *Simiadæ*,—they are broad and flat, but usually longer in the *Herbivora*; and in the Elephant, although far from proportionally broad in relation to the size of the brain, they are long and tapering. "Dans l'hypothèse," says SERRES, "que les pyramides sont les racines des lobes cérébraux, leur développement devrait être en raison directe de ceux-ci; or c'est ce qui n'est pas; les pyramides sont moins fortes chez l'homme que chez les singes; elles sont plus prononcées aussi chez les cétacées. Cette prédominence des pyramides se continue chez les carnassiers, le lion, l'ours, le raton, la loutre; chez les pachydèrmes et les ruminans†." *In relation to the size of the cerebrum*, it is true that the anterior pyramids are smaller in Man than in some of these animals, particularly the larger *Carnivora*, as the Lion and Hyæna; but *actually* their dimensions are in most instances much greater. In the *Herbivora* especially, the superficial breadth of the pyramids is no indication of their actual bulk, which can be ascertained only by means of transverse sections; for although they are frequently very broad, and rendered prominent at one part by the olivary bodies behind them, they are much more shallow than in Man, and their decussating fibres are much less numerous, as will be shown at a future page‡.

(9.) *Structure.*—Perhaps no question in anatomy has been the subject of greater dispute than that which concerns the *decussation* of the anterior pyramids. The opponents have been nearly equal in number and celebrity, and the confidence with which they have maintained their opinions has rendered the case somewhat remarkable§.

* Cerebri Anatome, cap. 3 (1664). † Anatomie Comparée du Cerveau, tom. ii. p. 187.

‡ I must acknowledge the readiness and kindness with which Mr. QUEKETT and Mr. MURIE, of the Royal College of Surgeons, assisted me in procuring the brains of many of these animals.

§ For instance, SANTORINI, speaking of the decussation, observes, "Nos autem sic eam luculenter conspeximus, sic evidenter, ubi apta incidere cadavera demonstravimus, ut nulla ampliùs nobis de hac re supersit dubitandi ratio" (Observationes Anatomicæ, cap. iii. 1724). On the other hand, the illustrious and laborious HALLER, after describing the anterior median sulcus, continues, "Hanc rimam si diduxeris, fibræ quasi medullares adparent, quæ a dextra columna medullæ oblongatæ in sinistram transeunt, transversæ

The decussation was first asserted by DOMENICO MISTICHELLI in 1709*. It was confirmed and more clearly pointed out the following year by the excellent POURFOUR DU PETIT†; and has since been described by SANTORINI, RACHETTI, WINSLOW, LIEUTAUD, SCARPA, GALL, DUVERNEY, SŒMMERING, VALENTIN, BURDACH, TIEDEMANN, ROSENTHAL, CRUVEILHIER, SERRES, REID, FOVILLE, SOLLY, KÖLLIKER. On the other hand, it has been denied by HALLER, MORGAGNI, BOYER, SABATIER, CHAUSSIER, PROCHASKA, VICQ D'AZYR, DUMAS, BICHAT, ROLANDO, MUNRO, DESMOULINS, and more recently by STILLING‡. At the present day the balance of opinion is decidedly in favour of a decussation, although the late microscopical researches of STILLING may have added some weight to the opposite side§. I am prepared, however, to place the fact beyond all possibility of doubt; for a cursory inspection of my preparations is sufficient to show that a complete and complicated decussation actually takes place. But still the real composition and elementary structure of the pyramids, as I shall now proceed to show, has not hitherto been accurately described.

(10.) Until the commencement of the present century, it was believed by those who admitted the fact in question, that the anterior pyramids are formed by a decussation between the *anterior* columns of the spinal chord. ROSENTHAL || corrected this error by pointing out the important fact that the fibres of decussation proceed from the *lateral columns*; but at the same time he thought that from the latter the whole of the pyramids are formed as new or separate structures by running along the fissure between the anterior columns, which they thrust aside in their course. Such is still the general opinion, but such is not the correct one, as I shall endeavour shortly to explain.

(11.) At the lower extremity of the human *medulla oblongata* (figs. 10 and 11, Plates XII. and XIII.), the *posterior* and *lateral white* columns are *broader* and *deeper*, but the *anterior* (I) are in every way *less* than in the dorsal or lumbar region. The central canal is entirely closed by a mass of granular matter, and is much nearer the bottom of the

quidem, quas nunquam, cum sæpe inquisivissem, vidi decussari, aut ad obliquos se secare angulos."—Elementa Physiologiæ, lib. x. tom. iv. p. 80.

* Trattato dell' Apopplesia, cap. iv. p. 13. As the work is uncommon, and I have not seen the passage that is referred to anywhere quoted, I here subjoin the principal portion. "Arrivati all' intorno, e ultimo velame si è osservato, che tutto quel caudice al di fuori si può assomigliare ad una treccia di Donna, posciache molti manipoli di fibre rette sono sovraposti à molti trasversali, molti obliqui alli trasversali, et alli retti, e seguitando questo intrecciamento ciascun ordine ritorno à sovraporsi, e sottoporsi, sinche le dette fibre escano dalla treccia trasversalmente per formare li nervi spinali, che sono ne i lati."

† Lettres d'un Médecin des Hopitaux du Roi. Namur, 4to. p. 12; accompanied with figures, which are very far superior to those of MISTICHELLI.

‡ Ueber die Medulla Oblongata.

§ "A crossing of the pyramid-fibres is nowhere to be perceived," he says, "Eine Kreuzung der Pyramidenfasern ist nirgends wahrzunehmen." He attributes such an appearance to the unsymmetrical manner in which the alternate bundles on each side meet and indigitate (Ueber die Medulla Oblongata, p. 29). He also describes these bundles of fibres as arising from the anterior commissure at the bottom of the fissure, p. 27.

|| Ein Beitrag zur Encephalotomie. 8vo. Weimar, 1815.

anterior than of the *posterior* median sulcus; for the grey substance behind it has become more ample than in any region of the *medulla spinalis*; so that with the lateral portions it presents a kind of quadrilateral mass, which is prolonged in front and behind, on either side, to form the anterior and posterior cornua. The *anterior* cornu is thick, club-shaped, short, yet reaches nearly to the surface, for the corresponding white column is extremely shallow. The *posterior* cornu, on the contrary, is very slender and long, and projects obliquely backwards to within a line or two of the surface, where it expands into a kind of tuft, or irregularly oval mass (f), which is frequently broken into two parts, of which the most anterior is sunk, as it were, in the lateral column. This tuft or expanded portion might be termed the *caput* cornûs, and its long and narrow portion, the *cervix*. The outer part, or border of the *caput* cornûs, is the *gelatinous substance*; its interior is more opake, and pierced by a multitude of longitudinal bundles. The *cervix* cornûs is also intersected by a number of nearly flat longitudinal bundles, which in a transverse section appear as fusiform streaks in its course. Many of the fibres of the posterior nerve-roots (f'), after traversing the gelatinous substance, run out and disperse through the posterior column (see fig. 11 f'''); some cross over to the opposite side, behind the central canal; the rest, between the flat longitudinal bundles, curve forward to the anterior cornu, and in part run out at intervals through the antero-lateral column. The gelatinous substance contains numerous small and large cells, which are spherical, oval, fusiform, and triangular; and the *cervix* cornûs abounds with others of small average size and which are often extremely minute: these are oval in various degrees, or exceedingly fusiform in the direction of the fibres, with which their processes, extending to a great length, run side by side, or parallel. The whole lateral portion of the central grey substance (figs. 10 and 11) contains cells of the same kind, with a crowd of others that are spherical, oval or angular, but of great disparity in size: the smallest are less than the $\frac{1}{4000}$th of an inch in diameter, while some of the largest are nearly equal to those of the anterior cornu.

(12.) From the lateral border of the entire grey substance (figs. 10 and 11), a beautiful network of blood-vessels and fibres is prolonged through the lateral column, which is divided by its meshes into a multitude of separate fasciculi of different shapes and thickness. With the fibres, which at first are but few, a number of cells, like those of the grey substance, extend through the network, and are apparently connected with each other between the fasciculi of the white columns. Those of the anterior part (fig. 10), in Man, are by far the most abundant and the largest; they are oval, fusiform, triangular or variously branched, and may not only be traced uninterruptedly to the very centre of the anterior cornu, but many of the most distant, off the skirts of the network, are connected with it by processes of remarkable length.

(13.) It is from the fasciculi of the lateral column, enclosed in the meshes of this network, that the fibres proceed in a transverse direction, with others from the grey substance, to form the chief portion of the opposite anterior pyramid (see figs. 11 and 12). As they bend round to take this direction, they interlace and intertwine in a very intri-

cate manner (fig. 12, Plate XIII.), and then crossing in several bundles the anterior grey substance, they reach the commissure in front of the spinal canal, where they decussate by platting with those of the opposite side. Now, when in a transverse and slightly oblique section through the commencement of the pyramids, these fibres were examined with a sufficiently high magnifying-power, I found that they were not prolonged into the anterior fissure and laid as an entirely separate structure along the inner border of the opposite anterior column, but that they plunged into its very substance and became incorporated with it, sometimes near its inner margin, and sometimes more externally. By the extension upwards of this process, the anterior columns, already swollen by the incorporated fibres of the previous decussation, continue to increase in bulk, and project above the level of the olivary columns as two rounded chords. It is known that the outer portion of each pyramid consists of parallel fibres, which are nowhere involved in the decussation, and were supposed by ROSENTHAL to be derived from the lateral column of the same side. These belong to the outer and sometimes deeper portion only of the anterior column, which has not been traversed by the oblique decussating fibres*.

(14.) In addition to the fibres that proceed from the lateral columns and posterior grey substance, there are other decussating fibres that enter into the composition of the anterior pyramids. These are derived from the anterior grey substance, and belong to the system which constitutes the anterior commissure of the *medulla spinalis*. They are less numerous, however, and most distinctly seen at the lower parts of the pyramids (see figs. 11 and 19).

(15.) The anterior pyramids, therefore, are composed of four orders of fibres:—

1. Decussating fibres from the lateral columns, forming their chief bulk.
2. Decussating fibres from the posterior columns and posterior grey substance, particularly at their upper portion.
3. Decussating fibres from the anterior commissure.
4. Non-decussating fibres of the anterior columns, separate on their outer side, and on their inner side incorporated with those that form the decussation.

(16.) Before the fourth month of fœtal life, as TIEDEMANN has well observed†, the pyramids are broad and flat, and have some resemblance, externally, to the pyramidal anterior columns in the *medulla oblongata* of fishes (fig. 1, Plate XII.). At the fifth month they begin to project above the level of the surface, and continue until birth to increase in depth, in consequence of the continual reinforcement they receive from the decussating fibres of the lateral columns chiefly. The decussation may be observed from the fourth to the sixth week. I have repeatedly tried to make transparent sections of the fœtal medulla, but owing to its soft and friable texture, have not succeeded.

* This non-decussating portion of the pyramids is correctly described by Dr. SHARPEY (QUAIN's 'Anatomy') and by Mr. SOLLY (Human Brain) as belonging to the anterior column, but they considered it as the whole of that column.

† Anatomie de Cerveau, traduit par JOURDAN (1823), p. 145.

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(17.) In Mammalia, the decussating fibres are much less numerous than in Man. Generally, I have found their number to be in the direct ratio of the *prominence*, rather than the *breadth*, of the pyramids. They proceed more from the *deep* strata of the lateral columns, and less from the *superficial* and *anterior*; so that the whole decussation, as will be seen further on, resembles rather the *upper* portion of that in Man (compare fig. 12 with figs. 13, 15, 16 and 17). In the Cat it is stronger than in the Dog, Sheep or Ox, and a transparent section through it presents a very beautiful appearance. A transverse section of the *medulla oblongata* of the *Tiger* bears in every respect a most striking resemblance to that of the Cat: the decussating fibres are numerous, and the anterior pyramids are consequently prominent and deep, so that *relatively to the size of the cerebrum*, they are decidedly *larger* than in Man. In the Guinea Pig also the decussation is well marked, and the fibres it derives from the posterior columns and the grey substance may be very distinctly seen (see fig. 17, Plate XIII.).

(18.) Anatomists are divided in opinion with regard to the existence of the anterior pyramids in Birds, Reptiles and Fishes. Like WILLIS, HALLER, VICQ D'AZYR, DESMOULINS, LEURET and others, I have never seen on the surface of the medulla in birds any distinct pyramidal columns resembling those of the higher animals; but in a transparent transverse section through the point (*i*), fig. 2, Plate XII., at the level of the hypoglossal nerves, a decided decussation may be observed (see fig. 18, Plate XIII.): its fibres, however, are not much more numerous than those of the anterior commissure of the spinal chord, and, like them, are scattered and lost in the substance of the anterior columns. Although, therefore, it cannot be said that distinct pyramidal columns exist in birds, yet LEURET was mistaken, when, in reference to the fibres of their spinal chord, he observed, "D'abord ces fibres ne se croisent pas dans la moëlle allongée, où l'on chercherait vainement une disposition analogue à celle des corps pyramidaux*."

(19.) In Fishes, there appears to be a slight decussation of fibres proceeding from the posterior portions of the medulla, but it is not very distinct.

(20.) The *posterior columns* in Mammalia and in Birds are broad, but shallower than in Man (compare *a*, in figs. 10 and 11, with *a* in figs. 13, 14, 15, 16, 17 and 18). In the Dog, the posterior pyramids have a peculiar shape, each arising from the bottom of the fissure as a thin lamina, which widens towards the surface in the form of a wedge (see fig. 16 *b*).

(21.) As the fibres leave the lateral columns to decussate into the anterior pyramids, the posterior cornua sink, as it were, forwards, and therefore extend more and more towards the sides of the medulla, where their terminal tufts, gradually increasing in bulk, and reaching the surface, form the columns called the grey tubercles of ROLANDO (see fig. 19). At the same time, on each side of, and close to, the posterior median

* Anatomie Comparée du Système Nerveux, tom. 1[er], p. 296.

fissure, a small conical eminence may be observed to arise from the posterior border of the central grey mass, from which a network of blood-vessels and radiating fibres extend directly backwards through the posterior pyramid (*b*, figs. 12 and 19). Within the eminence and amongst the network, are developed a number of cells, which for the most part are circular, oval, or pyriform, and give off two processes or more, in both a transverse and longitudinal direction. Fig. 20, Plate XIII., represents them magnified 420 diameters. Each cell contains a distinct nucleus and nucleolus, with a mass of yellow pigment-granules accumulated on one side, or at one extremity. Further outwards, from the root of the *cervix* cornûs, a larger and gradually increasing eminence arises in the same way, and projects through the base of the restiform body, towards the surface of which it sends forth a number of radiating fibres (see *b*, figs. 12 and 19); but its cells, though precisely similar in structure and shape, are superior in size, to those of the former (fig. 21, Plate XIII.). The fibres of both are delicate tubules of small average diameter, and for the most part without double contours. They radiate in tapering and irregular bundles, which interlace with those of the restiform body, where they become longitudinal in part, and are partly continuous at the surface with the superficial layer of arciform fibres.

(22.) These new productions of grey substance will be distinguished respectively as the *post-pyramidal* and *restiform* nuclei, or ganglia. They exist in all the Mammalia, and to a certain extent in Birds. In some of the former animals—in the Cat, for instance,—the restiform nuclei are very largely developed and nearly fill the white column.

(23.) Coincident with these changes, others are taking place towards the sides and front of the medulla; for the anterior cornu becomes gradually divided and subdivided into smaller portions by longitudinal fasciculi of various sizes, around which they mostly communicate (see fig. 11); and from these subdivisions fibres run outwards in great numbers. By the extension of this process, the whole of the cornu is at length resolved into network, which spreads through the lateral column. At the same time the fibres of the network, formerly described as arising from the side of the *posterior cornu* and of the *central grey substance*, continue to increase in number. At first they are crossed, interlaced and very much obscured by those of the decussation proceeding from the bundles enclosed in the meshes which they form; but as the decussation diminishes, the network, still further developed, comes clearly into view, and, in continuity with that of the anterior cornu, appears in the form of a wing with its point directed forwards (see figs. 13, 16 and 19). The network contains a multitude of cells which differ in shape and size. Many are variously fusiform, and appear at intervals in the course of fibres like mere dilatations, which are sometimes exceedingly small; others are oval, triangular, semilunar, or irregular in form, and send out their processes in different directions between the bundles of the lateral column, which they often closely embrace. This arrangement is distinctly seen in Mammalia, Birds, and in Fishes; in the first of these classes the network is rather coarser, and the cells larger and more abundant than in

Man*. Fig. 13, Plate XII. represents a transverse section of the *medulla oblongata* of the Sheep, just below the olivary bodies; and fig. 14, a similar section through their lower ends.

(24.) When nearly the whole of the anterior cornu has become resolved into network, at its root in front of the central canal, a new and gradually increasing column of vesicular substance begins to make its appearance. This is the ganglion or nucleus of the hypoglossal nerve, the lowest fibres of which run out through the remains of the cornu, like roots of the spinal nerves (see fig. 13, Plate XII.). Behind the canal, and on each side, another vesicular column may be observed, at the same time, in process of formation. This is the nucleus or ganglion of *the spinal-accessory nerve.*

(25.) Fig. 23, Plate XIV. represents a transverse section of the human *medulla oblongata*, a little below the olivary bodies†. Here it will be seen that the vesicular mass within the restiform body (*a*) has increased to a considerable extent, and that the network developed in the posterior pyramid (*b*) has spread through the whole of its substance, while the cells in both are multiplied in an equal proportion, and lie scattered at large, or collected into small groups about bundles of longitudinal fibres. The *caput cornûs posterioris*, or *tuberculo cinereo*, also (*f*), has enlarged its dimensions, and is now crowded with cells, of which some are exceedingly small; they are similar, in structure and shape, to those in the posterior columns, and, like them, are connected with a number of fibres which they appear to generate from their processes. The central canal is more or less pervious, but generally compressed at the sides, sometimes to a mere line. It is lined with a very distinct layer of columnar epithelium, like that which I first pointed out in the spinal chord‡. Behind it on each side is the commencement of the *spinal-accessory nucleus*, the cells of which, apparently in different states of development, are pyriform, round, triangular or variously fusiform: they are mostly pale and exceedingly delicate, but many are partially or entirely filled with granules of yellow or dark brown pigment: this is especially the case with the fusiform variety, which are frequently ranged in linear series by the junction of their processes, which would seem to be forming into nerve-fibres. Between the posterior parts of the

* I am inclined to think that some of the smallest of these cells belong to connective and fibrous tissue. In every part of the grey substance of the spinal chord they are also very abundant, and often resemble exactly the formative cells of elastic tissue.

† I have chosen this part for an enlarged representation, because it is the point where nearly all the most important changes in the structure of the medulla are seen at the same time, and in close connexion with each other. The details were observed under powers varying from 150 to 420 diameters, without any pressure or displacement whatever.

‡ It is stated by STILLING, in his new work on the spinal chord (Neue Untersuchungen, Erste Lieferung, p. 20), that I was directed by BOWMAN to the discovery of these cells. This is a mistake, but one, perhaps, which might not unreasonably follow from the wording of my own note (Philosophical Transactions, 1851, Part II. p. 614). However, the fact is, that having observed this structure around the spinal canal, without deciding on its nature, I pointed it out to Mr. BOWMAN, who *then* suggested that, perhaps, it was epithelium, which on *further* examination in a perfectly fresh state, I found to be the case.

spinal-accessory nuclei, at the bottom of the median fissure, is a transverse commissural band divided on each side by a longitudinal column into two portions, which again unite, and becoming continuous with cells, either single or in linear series, run partly behind and partly through the nucleus and network in the lateral column as fibres of the accessory nerve. In front of the canal are the first-formed cells of the *hypoglossal nucleus*; and a little further forward is the *non*-decussating portion (I) of the anterior pyramid, consisting of that outer and deep part of the anterior column at the side of the sulcus (I, figs. 11, 12 and 19) which remained unmixed with the decussating bundles from the opposite lateral column, but is now crossed at its posterior half by those of its own side, which divide it into smaller fasciculi. The anterior cornu which lay on its outer side is wholly resolved into network (represented in the left half of the figure 23); but amongst this network (omitted on the right side) may still be observed a number of small fusiform cells, sometimes pigmentary, and joined in linear series; and with these are a few others that are larger, oval, fusiform and triangular, and lie mostly with their longer axes and processes parallel with a multitude of fine fibres, which running obliquely outwards, in part form the roots of the hypoglossal nerve. Traced backwards, these fibres are found to have various destinations. Some of the innermost layer bend forward round the root of the pyramid and join in the decussation; a few run obliquely backwards round the opposite side of the canal, in front of which they first decussate with their opposite fellows, and become continuous with cells that are often darkened by pigment; the rest take their origin from the cells of the nucleus. Scattered in part amongst these fibres, and partly resting in masses on the back of the pyramid, is a multitude of cells much smaller than the rest, which form the commencement of the olivary lamina. In the posterior part of the lateral column, amongst the network in front of the *caput cornûs posterioris*, is seen a remarkable group of large stellate, pyriform and fusiform cells (p), which send out their processes to a great length between the longitudinal bundles enclosed in the meshes; and nearer the anterior and outer part of the same column is another curious group (g), to be described further on. The decussation of the anterior pyramids, though still considerable, is very much reduced; for the fibres it derives from the lateral columns, which at first were its principal source, have become comparatively few, while those that proceed from the posterior columns and central grey substance have been gradually increasing in number, though not in a corresponding inverse proportion. From before backwards the decussating bundles may be traced round the sides of the central canal, where the fibres of each spread out and interlace with the rest in a series of curves and undulations. Some are continuous with the deep longitudinal bundles of the lateral columns; others run outwards to the plexus or network at the root or base of the *caput cornûs posterioris*; the rest extend backwards, and of these, some wander amongst and end in the cells of the central grey substance, while others are prolonged through the posterior columns.

Of the Corpora Olivaria.

(26.) The *corpora olivaria* were first made known by EUSTACHIUS in his eighteenth plate, and were so named by VIEUSSENS. Although denied by ROLANDO, LEURET, LONGET and some others, they are certainly found not only in Mammalia, but even to a certain extent in Birds; but differ somewhat in form. In Man they are larger than in any of the inferior animals, except the Elephant; and next in dimensions are those of the Ape-tribe and Cetacea (Dolphin and Porpoise).

(27.) *Structure.*—In Man each corpus olivare is separated from the pons by a deep depression, which in animals is occupied by a broad band called the *trapezium* (see figs. 3, 4, 7, 9). Its surface consists of two layers of fibres, transverse and longitudinal: the former belong to the arciform system, the latter are continuous with the antero-lateral column on the outer side of the pyramid. It is well known, that in a transverse section, the *corpus dentatum*, or grey substance of the olive, appears in the form of a convoluted lamina reflected upon itself at the surface, or like the longitudinal section of a sac placed transversely and somewhat obliquely with its mouth near the raphè and its fundus at the surface (see figs. 28 *et seq.*, Plate XVI.). In such a section the folds of the lamina are more or less at right angles to its course; but in sections made longitudinally and in intermediate directions they are seen to be prolonged sideways, and to be continuous with others in different planes and at various angles; so that the entire area of the sac is unequally and diversely undulated. Fig. 24, Plate XV. represents a longitudinal section with part of the olivary (white) column. Here the convolutions are seen to bear a striking resemblance to those of the cerebral hemispheres, for they are formed on the same plan; and, like them, the vesicular sac encloses a white nucleus of fine tubular fibres, which have the same kind of relation to its folds as the central fibres of the hemispheres have to *their* convolutions; and further, it is joined to its fellow of the opposite side by a transverse commissure, consisting of separate bundles, which communicate, however, and cross the raphè behind the anterior fissure (figs. 30, 31, 32). The average thickness of the lamina is about $\frac{1}{80}$th of an inch. Its cells are of small but rather uniform size, and measure from $\frac{1}{1300}$th to the $\frac{1}{1600}$th of an inch in diameter; but in shape they vary from the globular to the oval, the pyriform, the prismatic, and the semilunar, according, apparently, to the number, relative distance and direction of their processes: these are generally numerous: I have seen as many as eight proceeding from one cell: they extend in different directions, transverse, longitudinal and oblique, and are broad at their origin, but frequently taper rapidly like a short spur, or divide abruptly into several branches, which become continuous with the nerve-fibres (see fig. 22, Plate XIII., and fig. 25, Plate XV.). Each cell encloses a large globular or elliptical nucleus, containing a very distinct nucleolus.

(28.) Behind the olivary sac is a separate elongated mass composed of the same kind of cells; and a similar but larger mass (broken into parts by bundles of the deep arciform fibres) is found in front of the lamina, near the side of the raphè. The former

is called by STILLING the accessory olivary nucleus, and the latter, the large nucleus of the pyramid. I believe they are both parts of the olivary folds.

(29.) As may be seen in fig. 23, Plate XIV., it is amongst the network into which the anterior cornu is resolved, and through the outer portion of the anterior column by which it was surrounded, that the olivary body is developed. Immediately below the inferior rounded extremity of the olive, the cells are not arranged in the form of a convolution, but scattered at large (fig. 24, Plate XV.). Many of them are elongated also in the direction of the column and are distinctly continuous with some of its fibres; but the *bundles* of fibres pass on to the sac and diverge (see fig. 24, Plate XV.). The superficial layer bends forwards and outwards, and running longitudinally along the surface, sends some of its fibres in succession between the outer convolutions of the lamina, and then proceeds onwards through the pons; the bundles of the deep layer spread out in the olive, passing through and between the remaining convolutions, and forming a large portion of the central nucleus. In relation to the lamina, the course and arrangement of the fibres of the sac are very complicated, and not easily described with perspicuity*. Fig. 25, Plate XV. represents a series of convolutions from the posterior wall of the sac, with part of the central nucleus (O, O), as seen in a transverse section. The convolutions are turned with their convexities alternately *towards* and *from* the nucleus or interior of the sac, and the concavity of each is occupied by a bundle or process of fine tubular fibres, which diverge within it. The *bundles*, then, are alternately *within* and *without* the cavity of the sac, but a great many fibres of the one set are continuous with those of the other through the vesicular lamina or wall. They assume the form of the convolutions, and sometimes divide into two or three branches, which receive convolutions between them. For convenience of description, the fibres of each bundle may be divided into two sets. On selecting an inner bundle (P) or process of the central nucleus (O), it may be seen,—1st, that the fibres at its centre or axis proceed in straight lines nearly to the summit of the convolution, where some of them terminate in cells of the lamina, and some form a series of curves or tortuous loops between them; while others pass through the lamina either singly or in small bundles, and cross each other in a tortuous course towards the posterior part of the medulla (Q). 2ndly. The lateral fibres of the bundle are successively more divergent towards its base: some of them terminate in cells; but the rest in large numbers pass through the lamina to the next *outer* and *inverted* bundle on each side, from the bases of which they partly turn round the summit of the convolution to form a band of some depth, and partly diverge to the posterior region of the medulla (Q), where they cross each other with different degrees of obliquity and join the arciform plexus (see fig. 36, Plate XVII. x''). Traced towards the interior of the sac, the fibres near the *middle* or axis of the bundle (P) diverge through the nucleus (O, O), while those at the *side* of its base turn round the extremity of the next convolution (R) to be continuous with the *nearer* side of the next inner

* It has cost me extraordinary time and trouble to arrive at a satisfactory conclusion on this very difficult point; and I succeeded only by a still further modification of my method.

bundle (P′), and through the lamina, with the *further* side of the outer and intervening bundle (Q′); and so on through the rest of the lamina; but although these latter fibres appear to follow the course of the convolutions, I think that at intervals they terminate in cells. At the antero-lateral parts of the sac, the axial fibres of the *outer* bundles form the crust of the olive (see figs. 28 *et seq.*, Plate XVI.), and are continuous, on the one hand, with longitudinal fibres of the olivary column, and on the other hand, with the transverse olivary commissure and the system of arciform fibres. On the left side of fig. 25, Plate XV., the cells of the lamina are faithfully represented *in situ*, and in connexion some of the fibres. The olivary bodies, then, are intimately connected with all the surrounding parts of the medulla, chiefly through the arciform system, as will be more fully shown further on; but I have never been able to trace any immediate connexion between the cells of the lamina and the roots of the nerves,—not even of the hypoglossal nerves which pass directly through it. It is probable, therefore, that the *olivary bodies* are coordinating centres for the different ganglia or nuclei of the *medulla oblongata.*

(30.) The description thus given of the course of these fibres appears to be highly important, not only in reference to the structure of the olive, but on account also of the light it would seem to throw on the structure of the cerebral hemisphere; for since in both these organs the convolutions are formed on precisely the same plan, and have precisely the same relation to the *bundles* proceeding from the *nucleus*, it is highly probable that the *fibres* of these bundles, in both cases, have the same destination and course; indeed something of the kind in the cerebral convolutions has been already made out by more than one observer. The existence of the *outer* bundles connecting the olive with distant parts does not interfere with the comparison.

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Corpora Olivaria of Mammalia and Birds.

(31.) While in Mammalia the actual existence of the olivary bodies is denied by many anatomists, to those who admit them, their form, structure; and connexions may be considered as unknown. I shall therefore describe them in one or two animals of this class.

(32.) In the *Simiadæ*, the olivary bodies are prominent at the surface, but vary somewhat in size and shape in different genera. In *Cercopithecus* and *Semnopithecus* (figs. 38 and 39, Plate XVII.) they are more or less oval; while in the *Wanderoo* (fig. 40), they are more semilunar, as in the *Bear* and *Seal* (fig. 41). Figs. 7 and 8, Plate XII. represent side views of the *medulla oblongata* of the *Sheep*, and figs. 3 and 4 exhibit front views of the medullæ of the *Cat* and *Dog*, with parts of the cerebrum and cerebellum. As it ascends from the points of the anterior pyramids, the *medulla oblongata* becomes much enlarged, and rather suddenly forms in front a projection which varies in extent in different animals. At the base of the pyramids and the lower border of the *pons* is a

broad band, called the *trapezium* or inferior *pons* (*s*), which in the *Cat* and other animals of the feline species is very prominent on each side*. Along the outer border of the pyramid is a narrow column, which is not so distinct in some animals. This is the *olivary* column as it appears at the surface. It bears near its middle a prominent mass, which is oval and small in the *Sheep* and *Cat*, but semilunar and larger in some animals, as the *Bear* and *Seal*. In the *Tiger* it resembles that of the *Cat*, and forms a long and somewhat crescentic band, the curve of the crescent embracing a corresponding convexity along the outer side of the pyramid. At its upper end, as may be seen in figs. 7 and 8, it sinks behind the pyramid, but is continuous, *below*, with a distinct but slender fasciculus (*h*) of the antero-lateral column. In the figures, the dots along its inner border indicate the attachment of the hypoglossal nerve. At (*i*) on each side, the anterior pyramid commences, and suddenly projects forward as an oblong swelling, which might be mistaken for an enlargement of the pyramid itself. But if a transverse section (fig. 14, Plate XII.) be made through the lower part of the protuberance, it may be seen that the decussation has already ceased, and is therefore very limited in extent. The pyramids (*i*, *i*) are consequently very shallow, but rendered prominent by the olivary bodies, which are chiefly imbedded behind them, and appear at the surface as a narrow column only. As in Man, each of these bodies consists of a vesicular sac enclosing a central nucleus; but the convolutions of the lamina are fewer and comparatively larger, as may be seen in fig. 26, Plate XV., which represents a transverse section through the middle of the protuberance of the medulla of the Sheep, in a plane passing through the point of the *calamus scriptorius*. It rests in a concavity of the pyramid, with one extremity at the side of the raphè. The opposite bodies are united by a transverse commissure, composed of separate bundles which undulate through them into the lateral columns to be continuous with the arciform system: immediately behind the pyramids some of these fibres form a very regular and wavy band. Fig. 27, Plate XV. represents a transverse section of the olivary bodies and pyramids in the Cat; those of the Guinea Pig are seen in fig. 17, Plate XIII., resting on the back of the pyramids. In the Simiadæ, the vesicular lamina, or *corpus dentatum*, is thrown into numerous convolutions, and has nearly the same shape and appearance as in Man.

(33.) The cells of the lamina vary somewhat in different orders. In the Ox, Sheep and Cat, they are about equal to those of Man, but many are more elongated. In the Guinea Pig they are not so large.

(34.) In Birds the cells are small and not arranged in a lamina, but scattered through the side of the anterior column (see fig. 18, Plate XIII.).

(35.) On the outer side of each olivary body, and separated from it by a groove which lodges the hypoglossal nerve, is another vesicular column of nearly the same length, but broader externally. It is rather cylindrical in the Cat (fig. 4, Plate XII.), fusiform in the Sheep (figs. 7 and 8), and in the Dog forms a broad swelling at its lower extremity.

* The *trapezium* is found in all the Simiadæ except the Chimpanzee, but varies in size, and is generally sunk deeply at the side of the olive.

Above, it blends as a flattened band with the trapezium, close to the origin of the facial nerve, which arises from the side of the latter (fig. 8); and below, it is continuous with a distinct fasciculus of the lateral column (q). From its side and that of the olivary body, the broad band of arciform fibres crosses the medulla to reach the posterior columns; but within, it is traversed by a network or plexus, formed by the interlacement of these fibres with those remaining from the anterior cornu, and enclosing the longitudinal bundles of the lateral column. Amongst this network lie the cells, which are larger than those of the olivary body and more irregular in shape. They are oval in different degrees, or pyriform, fusiform, crescentic, club-shaped, triangular, or variously stellate, and give off processes which nearly encircle the longitudinal bundles, and contribute to form the meshes. All these appearances may be very distinctly observed in the Sheep, Ox, or Cat

(36.) In Man a similar structure was found, but owing to the difference in the shape of the medulla, it lies behind, instead of at the side, of the olivary bodies, and is not so prominent externally (see figs. 23 and 28 g): the cells also are rather less than those of the Mammalia.

Of the Structural Changes in the upper part of the Medulla.

(37.) Through the lower fourth of the olivary bodies, the decussation diminishes in breadth, and at length becomes the raphè, the fibres of which are connected chiefly with the borders of the pyramids as part of the arciform system. But now there begins to be developed within the pyramids themselves, a new vesicular system, which increases as it ascends, and forms the chief part of the grey substance of the *pons Varolii*. Each pyramid in front and at its sides is pierced by blood-vessels of considerable size. One of these enters from the anterior sulcus, and running posteriorly, sends off from its side across the back of the pyramid a number of nearly horizontal branches, which communicate with those of another vessel that enters through the fissure on its outer side in front of the olivary body, as well as with each other by lateral branches and with those that enter in front of the pyramid. The transverse network at the back of the latter contains a number of scattered cells, which are small, but uniform in size, nucleated, and pigmentary; in shape they are oval, pyriform, more or less triangular, or very long and fusiform; they send out processes which either encircle the longitudinal bundles, or run along the small fissures towards the sides of the pyramid; so that they form a complete network of nearly single fibres. But at the inner side of the pyramid, near the bottom of the anterior sulcus and against the arciform fibres where they are continuous with the raphè, in the process of pia mater round the artery and its first branches from which the transverse network proceeds, there is formed a large vesicular mass (see A, fig. 36, Plate XVII.), which sends out tapering or pointed prolongations across the back of the pyramid, where the processes of their cells become continuous with those of the network just described; but the cells at the base of the mass are turned with their longer axes in the direction of the course of the arciform fibres, against which they

lie, and with some of which they are certainly continuous. Around the front of the pyramid there are several other more or less triangular masses of the same kind (A′), that send backwards a number of similar prolongations, from the cells of which a multitude of fibres radiate through the pyramid and partly disappear, probably to become longitudinal. Between these prolongations some of the fibres form loops within the border of the masses; and between the masses themselves, fibres proceeding from the substance of the pyramid run outwards to the arciform band at the surface, where they turn right and left, and form a series of loops by re-entering at different parts.

(38.) These vesicular masses, therefore, appear to generate new fibres in the pyramids, and new arciform fibres, the latter of which not only connect together different parts of the pyramids themselves, but, as we shall see further on, the system to which they belong establishes the most intimate communication between *all* parts of the medulla.

(39.) The *hypoglossal* and *spinal-accessory* nuclei continue to increase as they ascend, until, by the divergence and diminution of the posterior pyramids, they are exposed on the surface of the fourth ventricle. The first or *hypoglossal* consist of two cylindrical columns, which are separated from each other by the raphè, and situate at first in front and at the sides of the canal (see *t*, figs. 23, 28, 29, 30, 31, 32, 33). They contain a great number of oval, pyriform, fusiform and stellate cells, of large size, and precisely similar to those of the anterior cornu, and are surrounded on their outer sides by the network of the lateral column, which, as already shown, is also studded with cells of all shapes and dimensions. The processes of the hypoglossal cells are both longitudinal and transverse: of the latter kind (fig. 35, Plate XVII.), some extend backwards towards the spinal-accessory nucleus; others towards the raphè, with the fibres of which they are sometimes continuous; a third set run outwards, and escape through the network of the lateral column, as do those of the anterior cornu of the *medulla spinalis*; but the greater number are continuous in front with the fibres of their own nerve.

(40.) In Mammalia generally the nucleus and cells have nearly the same appearance as in Man. In Birds the nucleus is rather more posterior, and its cells are smaller, but in other respects similar (see fig. 18).

(41.) The *spinal-accessory* nucleus on each side is developed in great part from the posterior and lateral portion of the central grey substance. It appears at first as a narrow tract (*r*, fig. 28, Plate XVI.), which extends from the bottom of the posterior fissure, obliquely outwards and forwards, along the side of the canal, over which, with its opposite fellow, it forms a kind of slanting roof. It is overlaid by the root of the posterior pyramid, from which it is afterwards partly developed, and rests, as it extends forwards, on the back of the hypoglossal nucleus. Its anterior extremity divides into two portions or horns, which partially enclose some longitudinal bundles of the lateral column, and are continuous with the roots of its nerve. As the nucleus ascends the medulla, its posterior portion enlarges at the expense of the posterior pyramid, on the base and inner side of which it gradually encroaches. The majority of its cells are oval, pyriform or fusiform, and turned with their longer axes in the direction of the nerve;

they lie chiefly in the inner portion of the nucleus, contain distinct nuclei, and are remarkable for their transparency, which gives to the ganglion a peculiar, pearly aspect; but some, towards its outer extremity, are filled with dark brown or blood-red pigment-granules, and contain no nuclei (see fig. 23).

(42.) In Mammalia the form and colour of the ganglion are nearly the same as in Man; but the cells are larger, more elongated and less delicate, and none of them are filled with pigment-granules, as in the human medulla.

(43.) Like the vesicular columns just described, the *postpyramidal* and *restiform* ganglia continue to increase as they ascend, and by their lateral extension form nearly one continuous mass on each side of the medulla (fig. 28 *et seq.* Plate XVI.). The cells of the former spread through the whole of the pyramid, and are most numerous near the surface. In the superficial portion of the restiform body the interlacement of its own fibres with those radiating from its grey substance is extremely intricate (see fig. 36); it is loose and irregular, like that of a sponge, and contains in its interspaces a variable number of cells, which send out their processes to be continuous with fibres in all directions.

(44.) Figs. 23, 28, 29, 30, 31, 32 and 36, Plates XVI., XVII., represent a series of transverse sections, from the lower ends of the olivary bodies to the fourth ventricle. The *caput cornûs posterioris* is pierced at its root by longitudinal bundles, enclosed in the meshes of a plexus of the deep arciform fibres which proceed from the posterior columns (figs. 32 and 36). These longitudinal bundles are exceedingly interesting, for I have traced the continuity of some with the descending root of the trifacial nerve: in the angular spaces around them cells are imbedded, and between them the roots of the vagus and glossopharyngeal nerves proceed inwards to their ganglia.

(45.) The ganglia or nuclei of the *par vagum* commence with the fourth ventricle, and are directly continuous with the vesicular columns from which the accessory nerves take their origin. These vesicular columns, by encroaching on the bases and inner sides of the posterior pyramids, gradually rise to the surface, and diverging to form the point of the *calamus scriptorius*, enlarge into two pyriform masses along the inner border of the pyramid, from which they are partly developed * (*rr*, fig. 5, Plate XII.). Each has the same form as the spinal-accessory nucleus, and in the same way, its deeper portion, which lies beneath the pyramid, is divided into two horns by longitudinal bundles of the lateral column (see *r*, figs. 29, 30, 31, Plate XVI.). Its cells also are similar to those of the accessory nucleus, but more abundant (see fig. 37, Plate XVII.). I can find no other difference. At the point of the *calamus scriptorius* the two nuclei are joined by the upper

* These pyriform bodies are represented in GALL's plates, but were first described by ROLANDO as a portion of the central grey substance:—" Ces tubercules ne sont rien autre qu'une portion de la substance cendrée renfermée dans la moëlle épinière et la moëlle allongée, qu'on peut suivre vers le haut, jusqu'au quatrième ventricule, où elle se montre sous la forme de deux feuilles lancéolées de substance cendrée."—Recherches Anatomiques sur la Moëlle Allongée, 4to, p. 22. STILLING, however, has the merit of having first shown them to be the nuclei of the par vagum.

border of the transverse commissure, which forms the roof of the central canal. Beyond this point, therefore, the canal is laid open and expanded into the fourth ventricle, in the floor of which the vesicular column or nucleus of the *hypoglossal* nerve ascends on each side of the mesial line (see fig. 5, Plate XII.). Fig. 33, Plate XVI. represents a transverse section of the medulla of the Sheep at the point of the calamus scriptorius, where the transverse commissure bridges over the upper extremity of the canal. A similar section of the human medulla is represented in fig. 29, Plate XVI., where the commissure is broken and the canal laid open. Fig. 30 represents another transverse section about two lines higher up (between the points *a* and *r* in fig. 5, Plate XII.), in which the hypoglossal nuclei (*t*) are seen in the floor of the fourth ventricle. Near this point, the divergent extremities of the pyriform *vagal* nuclei *appear* to terminate abruptly; but in a transverse section, immediately beyond them, they are found to sink beneath two new masses of vesicular substance—the auditory ganglia (*v*, figs. 31, 32, 36)—which now begin to make their appearance at the sides of the medulla, and to which, in part, they appear to contribute. Here they gradually diminish, and become one of the nuclei or centres of origin of the glossopharyngeal nerves. At the last or highest roots of these nerves, which adjoin the anterior division of the auditory, there remains but a small group of their peculiar oval cells, to which separate divisions of the nerves find their way; while the rest of each nucleus becomes so gradually blended with the lower angle of the auditory ganglion, as not to be distinguished from it.

(46.) The arciform fibres which connect together the anterior and posterior portions of the medulla and its two lateral halves, are very numerous, and extremely intricate in their course and arrangement. They have been divided into two layers, *superficial* and *deep*; but both these layers are continuous, or intimately connected with each other at different points. The course of the superficial fibres has been already described (§ 5 and 6). At the back of the medulla they issue from the posterior columns, but chiefly from the restiform nucleus, and are then collected into a broad band (*x*, fig. 36, Plate XVII.), which proceeds transversely over the surface of the gelatinous substance. On reaching the lateral column they separate into bundles, which join the deep set and reunite with each other to form a plexus through the column of cells at the back of the olivary body (*g'*, figs. 29 and 32, Plate XVI.). The remaining fibres of the band advance round the surface of the olive and front of the pyramid to the anterior sulcus, as already stated.

(47.) The deep layer of arciform fibres may be said to arise, posteriorly, from the *post-pyramidal* and *restiform* ganglia, in which they are partly continuous with the superficial layer, either directly or through the medium of cells (figs. 31, 32, 33, 36). Collecting into bundles that join in an intricate plexus, they traverse first the *caput cornûs posterioris*, in which, with the horizontal roots of the *vagus* and *glossopharyngeal* nerves, they again interlace around the longitudinal fasciculi which ascend, as already stated, to the large root of the trifacial nerve. On arriving at the lateral column, the plexus expands through its whole breadth, but may be described in two parts,—the *lateral*

and the *deep*. The *lateral* portion, in front of the *caput cornûs*, communicates freely, as above described, with the superficial layer, and then sends forward a series of bundles that traverse and surround the *olivary body*. Its *outer* bundles (y) sweep round the front of the sac, and having sent in their course some fibres between its convolutions and into the white nucleus, they separate behind the pyramid into a series of other bundles which are gradually larger from before backwards, and communicate to form a small plexus, of which the finer or anterior portion, containing some cells, proceeds inwards and forwards through the pyramid to the vesicular nuclei (A, A′) along its border, while the coarser and posterior portion is continuous with the transverse olivary commissure. The *inner* bundles (x'') of the *lateral* plexus pierce the olive from behind, and winding through different parts of its substance, join the fibres of the white nucleus,—those internally at an angle,—and then proceed with them to form the principal part of the transverse commissure. The bundles of this commissure thus formed communicate with each other by lateral branches, as a plexus, and proceed to the edge of the raphè behind the anterior sulcus. Here they diverge and decussate freely in such a manner, that each exchanges fibres with *several* others of the *opposite* side that lie at different depths of the commissure, while the most divergent fibres from the *anterior* side of each bundle decussate to be continuous with the arciform band which runs round the opposite pyramid (see fig. 36 B).

(48.) The *deep* portion of the plexus from the lateral column, directly continuous with the other, or *olivary* portion, sweeps inwards to the remaining posterior part of the raphè, its main bundles curving backwards and becoming shorter as they approach the posterior surface (see figs. 29 and 30, Plate XVI.). Across the raphè they all diverge (see fig. 34, Plate XVII.), and like those of the olivary commissure, exchange fibres with bundles of the opposite side at a distance corresponding to their divergence, the central fibres of each crossing nearly in straight lines. Many of the most divergent, on reaching the opposite side, take an antero-posterior direction along the raphè, passing out singly and at intervals into different parts of the plexus and the longitudinal fasciculi enclosed in its meshes. At the summit of the medulla, the number of antero-posterior fibres is very much increased by considerable bands, which, proceeding from the auditory ganglia, and decussating at acute angles as they enter the raphè, run down it parallel to each other; and these bands at their decussation are crossed by that of two other bundles proceeding from the centre of the lateral columns and the remains of the glossopharyngeal nucleus (fig. 36, Plate XVII.).

(49.) The *raphè*, therefore, is the seat of a wonderfully complicated decussation between fibres from all parts of the *opposite* halves of the medulla, chiefly through the system of arciform fibres, which at the same time connect together all the parts of each *separate* half. The arciform plexus is everywhere interspersed with circular, oval, pyriform, fusiform, triangular or stellate cells, of different sizes, which give origin to some of its fibres, and frequently lie against the longitudinal fasciculi, with the fibres of which they are *probably* also continuous, for many of their processes run in the same direction.

Most of them contain a variable number of dark brown or blood-red pigment-granules. At the summit of the medulla, the raphè contains some oval and fusiform cells, lying with their longer axes parallel to it, and continuous with its fibres; and along each of its borders others of a similar kind are so numerous, that they form at intervals strata of considerable depth (see fig. 31, Plate XVI.).

Origin of the Nerves of the Medulla oblongata.

(50.) *Of the Spinal-accessory Nerve.*—It is well known that this nerve arises from the lateral column as low down as the sixth or seventh cervical vertebra. Its lowest rootlets, which are very delicate, may be traced to the lower part of the cervical enlargement, where they come off from the verge of the posterior-lateral fissure in company with the posterior roots of the spinal nerves; but its upper rootlets are attached in an irregular manner to nearly all the posterior half of the lateral column. At the lower part of the *medulla oblongata*, several large bundles proceed directly inwards to the side of the grey substance, midway between the anterior and posterior cornua, or a little below the level of the central canal. Here they bend forwards nearly at right angles into the anterior cornua, where their fibres separate and mingle with those of the anterior roots amongst the group cells (see g'', fig. 11, Plate XIII.). Higher up, even to the end of the pyramidal decussation, similar bundles may be seen, taking the same course forwards through the remains of the anterior cornu (fig. 19, Plate XV.). At the point where they bend round, there exists in animals a peculiar separate group of cells, of considerable size, which send their processes outwards to the lateral column. In Man, the whole lateral portion of the grey substance is filled with oval, pyriform, circular and fusiform cells, which are more or less pigmentary, of small average size, and lie thickly scattered, or at least are not collected into isolated groups. Some of these cells extend behind and at the side of the canal, and contribute to form the central nucleus of the accessory nerve. Towards this nucleus the remaining upper roots of the nerve proceed obliquely inwards and backwards (g'', fig. 28). The majority of their fibres are continuous with its cells, but some form a series or band of loops around the small mass of longitudinal fasciculi that separates its two horns: one bundle turns *inwards*, and after sending successively *forwards* a number of single fibres through the lateral network into which the anterior cornu is resolved, winds in front of the hypoglossal nucleus, and crossing the hypoglossal nerve, decussates with its fellow of the opposite side. These latter fibres are not so distinctly observable in Man as in some of the lower animals, for they are more delicate, less numerous, and, moreover, are obscured by the still decussating bundles of the anterior pyramids; but in the Ox, and particularly in the Sheep, they may be seen in the most satisfactory manner by means of a sufficiently-high power, and some of them may be traced even to the cells of the hypoglossal nucleus, where apparently they also form loops of continuation with the fibres of the hypoglossal nerve.

(51.) COLLINS, MALACARNE, VICQ D'AZYR, CUVIER, TIEDEMANN and others, were unable to find any separate *spinal-accessory* nerve in birds; but SERRES states that he has found

it in the Cassowary, the Ostrich, and the White Stork (*Ardea ciconia*), and that it joins the *vagus*, after ascending from the level of the posterior roots of the fourth spinal nerve *. In the domestic Fowl and some other birds, I have seen this nerve taking a similar course on the surface of the medulla; and in transverse sections of the *medulla oblongata* of the Ostrich, I have distinctly traced its roots through the lateral columns to their vesicular nucleus on each side, and a little behind the central canal. In many preparations which I have by me, the cells of this nucleus are beautifully shown.

(52.) *The Hypoglossal Nerve.*—In Man this nerve is attached to the surface of the medulla, along the *inner side* of the olivary body, between it and the pyramid; but in Mammalia, generally, it lies on its *outer* side, and in Quadrumana (the *Simiadæ*) it is attached to the olive itself, as is also the case in certain other animals in which that body is large. This diversity in the place of attachment of the hypoglossal nerve results from the difference in size of both the pyramids and olives in different animals; for where both these are small, there is ample room for the olive on the inner side of the nerve behind the pyramid; but where both are large, as in Man, the space internal to the nerve is occupied entirely by the pyramid, while the olive swells out beyond it. The nerve, in Man, proceeds inwards in several bundles, which wind at first in a sigmoid or serpentine manner through different parts of the olive, and then pass backwards, in nearly straight lines, to the nucleus in front of the central canal. Here their fibres diverge and cross each other in every direction (see fig. 35, Plate XVII.). Many are certainly continuous with processes of the cells; some turn outwards and run through the network between the bundles of the lateral columns, as do the anterior roots of the spinal nerves; others bend inwards and decussate through the raphè with their opposite fellows; while the rest pass backwards through their own nucleus to that of the accessory nerve. A similar course is observable in the Ox and Sheep.

(53.) In Birds the course of the hypoglossal roots is very peculiar. Proceeding inwards for a short distance, their fibres separate, and form, with the processes of cells and the longitudinal fibres of the white columns, an intricate plexus or network, on their way to their nucleus.

(54.) *Of the Vagus Nerve.*—The *vagus* nerve commences near the point of the *calamus scriptorius*. On their way inwards, its roots traverse, in several bundles, the gelatinous substance, and cross the plexus proceeding from the posterior columns, enclosing with it the longitudinal fasciculi which ascend to the large root of the trigeminus. They are therefore more horizontal in their course than those of the accessory nerve which runs in front of the gelatinous substance, but their fibres are distributed in nearly the same way; for some are continuous with the cells of the nucleus; others form loops around the group of longitudinal fasciculi between its two horns; while a *separate* bundle turns *inwards*, and after sending forwards in succession a number of single returning fibres, which wander through the network of the lateral column, proceeds through the side of the hypoglossal nucleus, where its fibres mingle with those of the hypoglossal

* Anatomie Comparée du Cerveau, tom. i^er. p. 502. and planche iv.

nerve,—I may almost affirm that some at least are continuous with the cells. Such is the course I have repeatedly observed in Man; and in the Sheep and Ox I can show, without any difficulty, that while some of the fibres of the last-mentioned *inner* bundle are apparently continuous with those of the hypoglossal nerve, others pass inwards to decussate through the raphè.

(55.) In Birds, since the posterior columns are comparatively shallow, and the gelatinous substance is consequently less advanced, the vagus nerve is on a level posterior to that in Mammalia, but its course within the medulla is nearly the same; for the separate origin of its fibres from its own nucleus and that of the hypoglossal nerve, as well as their decussation in front of the canal, are very distinctly and beautifully seen.

(56.) It has been already shown, that the vesicular column that gives origin to the accessory nerve, after reaching the surface of the fourth ventricle as the nucleus of the vagus, sinks beneath the auditory ganglion, and diminishing in size, becomes part of the nucleus of the glossopharyngeal nerve. Fig. 36, Plate XVII. represents exactly a transverse section of one-half of the human medulla at the uppermost roots of the vagus nerve (D). (*a*) is the restiform body; (*v*) the commencement of the *auditory ganglion*, formed out of the summit of the posterior pyramid, and apparently of part of the vagal nucleus; (*b*) is the deep portion of the posterior pyramid thrown aside and blending with the restiform body: it is traversed by a network of fibres, proceeding from the ganglion of the *portio mollis* (*v*) and containing a number of cells, which send out their processes between the longitudinal bundles represented by the dark spots; this network gives origin to the anterior or inferior division of the *auditory* nerve; (*r*) overlaid by the ganglion of the *portio mollis*, and partly blended with it, is the remainder of the nucleus of the vagus nerve, enclosing at its outer extremity its group of longitudinal bundles, which now adjoin those in the deep portion of the posterior pyramid; through the outer part of the nucleus, a number of fine fibres, proceeding from the network (*b*) in the posterior pyramid and across the ganglion of the *portio mollis*, extend inwards to the network in the lateral column; and around the head or inner extremity of the vagal nucleus, another band of fibres, issuing from the ganglion of the *portio mollis*, proceeds likewise to the lateral column; (*f*) is the extremity of the posterior cornu, pierced by longitudinal fasciculi and crossed by the deep plexus of arciform fibres proceeding from the posterior pyramid and the restiform body; along its inner or anterior margin (*l*) a bundle of fibres and a blood-vessel extends forwards and outwards through the lateral column, and more internally are two or three others, running in the same direction; (*t*) is the floor of the fourth ventricle; it is continuous with that of the central canal, and is likewise lined with columnar epithelium, which rests on a layer of fine fibres. Beneath the latter is another layer of fibres (t'), interspersed on each side, and partly continuous, with a number of oval cells, which lie with their longer axes parallel to them; in their course inwards the fibres run down the side of the raphè (t''), and in the opposite direction they extend round the surface of the auditory ganglion. Immediately beneath this layer, and resting on the inner part of the antero-lateral column, is the continuation

of the vesicular nucleus of the hypoglossal nerve, or the commencement of the *fasciculus teres*, from which, higher up, the *facial* and the *abducens* or sixth nerve have a common origin: it is filled with cells, which vary considerably in size, and are smaller than those of the hypoglossal nucleus: those nearest the raphè are the largest, and mostly oval or spherical. Proceeding from the front of this nucleus are two or three considerable bundles of fibres and several smaller ones, which run forwards and take nearly the same course as the hypoglossal nerves towards the olivary body: near their origin the network in the antero-lateral column, through which they pass, is crowded with cells, of all shapes and sizes, which send out their processes in every direction between the longitudinal fasciculi, and probably establish a most intimate union of the parts amongst which they lie. Some of the fibres of these bundles, as well as separate fibres issuing from the white column, may be traced into this nucleus; but others turn inwards, and after running along the border of the white column and lower part of the nucleus, they decussate through the raphè with their opposite fellows. Along each side of the raphè runs a considerable blood-vessel, which sends out lateral branches to follow the bundles of the plexus and anastomose with the vessels that accompany the antero-posterior bundles just described.

(57.) The *glossopharyngeal* nerve passes inwards and backwards, in two or three bundles, through the gelatinous substance and across the arciform fibres. On reaching the group of longitudinal fasciculi, which lie at the extremity of the vagal nucleus and now adjoin the network of the posterior pyramid, its outer portion separates, in a brush-like manner, into many smaller bundles, which subdivide the fasciculi into a corresponding number of parts, and interlace between and around them: many of its fibres at this point *appear* to become longitudinal; some turn into the auditory ganglion, along the lateral border of which they may be traced in part through the network of the posterior pyramid (*b*); the middle fibres of the nerve proceed to the remaining cells of the vagal nucleus, and many of them appear to extend as far as the group of cells that form the commencement of the *fasciculus teres* and the continuation of the hypoglossal nucleus: as in the case of the vagus, the anterior portion of the nerve, forming a distinct bundle, turns inwards round the summit of the antero-lateral column, and passing through the most anterior and largest cells, sends forward a series of returning loops, first through the antero-posterior bundles along the inner border of the *caput cornûs posterioris*, and then in succession through the network of the lateral column, as it makes its way towards the raphè (see fig. 36, Plate XVII.); but in this course its fibres lie side by side with those which have been already described as proceeding from the antero-lateral column in the same direction to decussate through the raphè with their opposite fellows, so that it becomes almost impossible to identify them and ascertain if they share in the decussation; that they do so, however, is rendered extremely probable by the fact that in Birds *all* the fibres of the eighth pair of nerves, of which the highest correspond to the *glossopharyngeal*, may be distinctly seen to decussate through the

raphè after passing through and around their nuclei. I have by me many preparations showing this course in the most satisfactory manner.

(58.) It has been shown that the grey substance behind the central canal, after forming the cells in the *post-pyramidal* ganglion, becomes itself the *nucleus of the eighth pair of nerves*, and increases by encroaching on the pyramid, to the remains of which it appears again to contribute for the formation of the *auditory ganglion*: there would seem, therefore, to be, if I may use the expression, a kind of family relationship between these two vesicular centres; and, moreover, the under or anterior division of the auditory nerve, which takes its origin from the network of the posterior pyramid behind the caput cornûs posterioris, adjoins the upper fibres of the glossopharyngeal, as the latter do those of the vagus.

Explanation of the Plates.

PLATE XII.

Fig. 1. Under surface of the brain of the Cod-fish:—A, olfactory nerves, attached to a delicate membrane; B, optic nerve, drawn aside; C, cerebral hemisphere, slightly wrinkled or folded; D, optic lobe; E, anterior column.

Fig. 2. Under surface of the brain of the domestic Fowl.

Fig. 3. Under surface of part of the brain of a young Dog:—F, crus cerebri; G, pons Varolii; H, part of the lateral lobe of the cerebellum; *s*, trapezium; g', vesicular column on the outer side of the olive.

Fig. 4. Under surface of a portion of the brain of a Cat:—C′, C′, middle and posterior lobes of the cerebrum.

Fig. 5. Posterior surface of the human *medulla oblongata*:—*a*, restiform body; *b*, *b*, posterior pyramids; *d*, *portio mollis* of the seventh nerve; *r*, *r*, vesicular columns or nuclei of the *hypoglossal* nerves, continuous with the *fasciculi teretes*; *t*, *t*, pyriform nuclei of the *vagus* nerves.

Fig. 6. Side view of the human *medulla oblongata*, enlarged:—*i*, anterior pyramid; *h*, olivary column; *g*, lateral column; *f*, *tuberculo cinereo*, or expanded extremity of the posterior cornu; *a*, restiform body; *b*, posterior pyramids.

Figs. 7, 8. Side views of the *medulla oblongata* of the Sheep:—*s*, trapezium; s', *portio dura* of the seventh nerve; s'', fifth nerve.

Fig. 9. Under surface of the *medulla oblongata* of the *Cheetah*, or hunting *Leopard*. The largely-developed *arciform* fibres are represented on the right side.

Fig. 10. Transverse section at the commencement of the human *medulla oblongata*:—*f*, caput cornûs, or expanded extremity of the posterior cornu; f'', posterior roots of the first cervical nerve; g'', spinal-accessory nerve; I, anterior columns.

Fig. 13. Transverse section of the *medulla oblongata* of the Sheep, at the lowest roots of the hypoglossal nerves z, z:—g'', spinal-accessory nerve proceeding through the network into which the lateral grey substance is resolved.

Fig. 14. Similar section through the lower part of the protuberance i' (fig. 8):—i, i, anterior pyramids enclosing the olivary bodies.

PLATE XIII.

Fig. 11. Transverse section of the human *medulla oblongata* at the point of the anterior pyramids, showing the commencement of the decussation:—i, i, anterior columns. The anterior cornua are pierced by numerous longitudinal bundles, amongst which the nerve-cells are scattered. A network of fibres from the lateral grey substance proceeds outwards between bundles of the lateral column: f''', fibres of the posterior roots running backwards through the posterior column.

Fig. 12. Oblique section from before backwards, through the lower part of the anterior pyramids, in the plane of the decussating fibres which proceed from the lateral columns:—a, commencement of the restiform ganglion; b, commencement of the post-pyramidal ganglion; i, i, anterior pyramids.

Fig. 15. Transverse section of the *medulla oblongata* of the Cat, through the broadest part of the decussation:—f, f, grey tubercles of ROLANDO.

Fig. 16. A similar section from the *medulla oblongata* of the Dog:—b, posterior pyramids.

Fig. 17. Similar section from the Guinea Pig.

Fig. 18. Transverse section of the *medulla oblongata* of the domestic Fowl:—g'', spinal-accessory nerve.

Fig. 20. Cells from the human *post-pyramidal ganglion*; magnified 420 diameters.

Fig. 21. Cells from the human *restiform ganglion*; magnified 420 diameters.

Fig. 22. Cells from the human *olivary body*; magnified 420 diameters.

PLATE XIV.

Fig. 23. A transverse section of the human *medulla oblongata*, immediately below the olivary bodies:—a, a, restiform bodies containing the restiform ganglia, or grey substance developed from the back of the *cervix cornûs posterioris*; b, b, posterior pyramids, containing the post-pyramidal ganglia; f, the grey tubercle of ROLANDO, or expanded extremity of the posterior cornu—the *caput cornûs*. At its root, d, fibres proceeding from the central part of the posterior grey substance are mixed in an intricate plexus, which encloses in its meshes numerous longitudinal bundles (represented by the dark spots), and contains a number of cells of different shapes (but represented by the small circles),

which send out their processes both transversely and longitudinally; *c*, are fibres radiating from the restiform ganglion, and from the decussation of the anterior pyramid of the opposite side, into the white substance of the restiform body; *g′*, a vesicular tract imbedded in the lateral column on the outer side of the olivary body. The group of small cells, resting on the back of the anterior pyramid, *i*, form the commencement of the olivary body; I, I, the non-decussating portions of the anterior pyramids; their posterior halves are divided into numerous bundles by the decussating fibres; *p*, a group of large stellate, oval, fusiform, pyriform and crescentic cells imbedded in the lateral column amongst the network represented on the opposite side of the figure: the whole of this network, enclosing longitudinal bundles, is interspersed with cells of different shapes and sizes, which frequently embrace the bundles, and send their processes longitudinally and transversely in different directions. Behind and on each side of the central canal is the commencement of the nucleus of the spinal-accessory nerve; and in front of it, on each side, is that of the hypoglossal nerve: *x* is the commencement of the superficial arciform fibres.

PLATE XV.

Fig. 24. Longitudinal section of the human olivary body, with part of the olivary column, showing the convolutions of the grey lamina, or *corpus dentatum.*

Fig. 25. A series of convolutions of the grey lamina of the human olivary body; on the left side the cells of the lamina are represented:—O, O, part of the central white nucleus; Q, Q′, Q, part of the antero-lateral column.

Fig. 26. Anterior pyramids, *i*, *i*, and olivary bodies, *k*, *k*, of the Sheep: on the left side the arciform fibres are seen winding through them.

Fig. 27. Anterior pyramids and olivary bodies of the Cat: the olivary commissure, joined by the arciform fibres, is seen decussating across the raphè.

PLATE XVI.

Fig. 28. Transverse section of the human *medulla oblongata* through the lower part of the olivary bodies:—r, *spinal-accessory nucleus*; g″, *spinal-accessory nerve*; t, *hypoglossal nucleus.*

Figs. 29, 30, 31, 32. A series of similar sections from the point of the *calamus scriptorius* to the upper roots of the *vagus* nerves (*f′*):—*x*, superficial arciform fibres.

Fig. 33. Transverse section of the *medulla oblongata* of the Sheep, immediately below the point of the *calamus scriptorius*:—*r*, *r*, vagal nuclei joined by their transverse commissure, which forms the roof of the upper extremity of the canal.

PLATE XVII.

Fig. 34. Part of the *raphè* of the human *medulla oblongata*. It is traversed from before backwards by numerous straight fibres, some of which are continuous with fusiform cells:—a', a' are bundles from the deep arciform plexus on each side, interspersed with cells of different shapes, and decussating through the *raphè*. Some of the fibres at the edge of the raphè form loops between the bundles; b, b are longitudinal fasciculi of the antero-lateral columns.

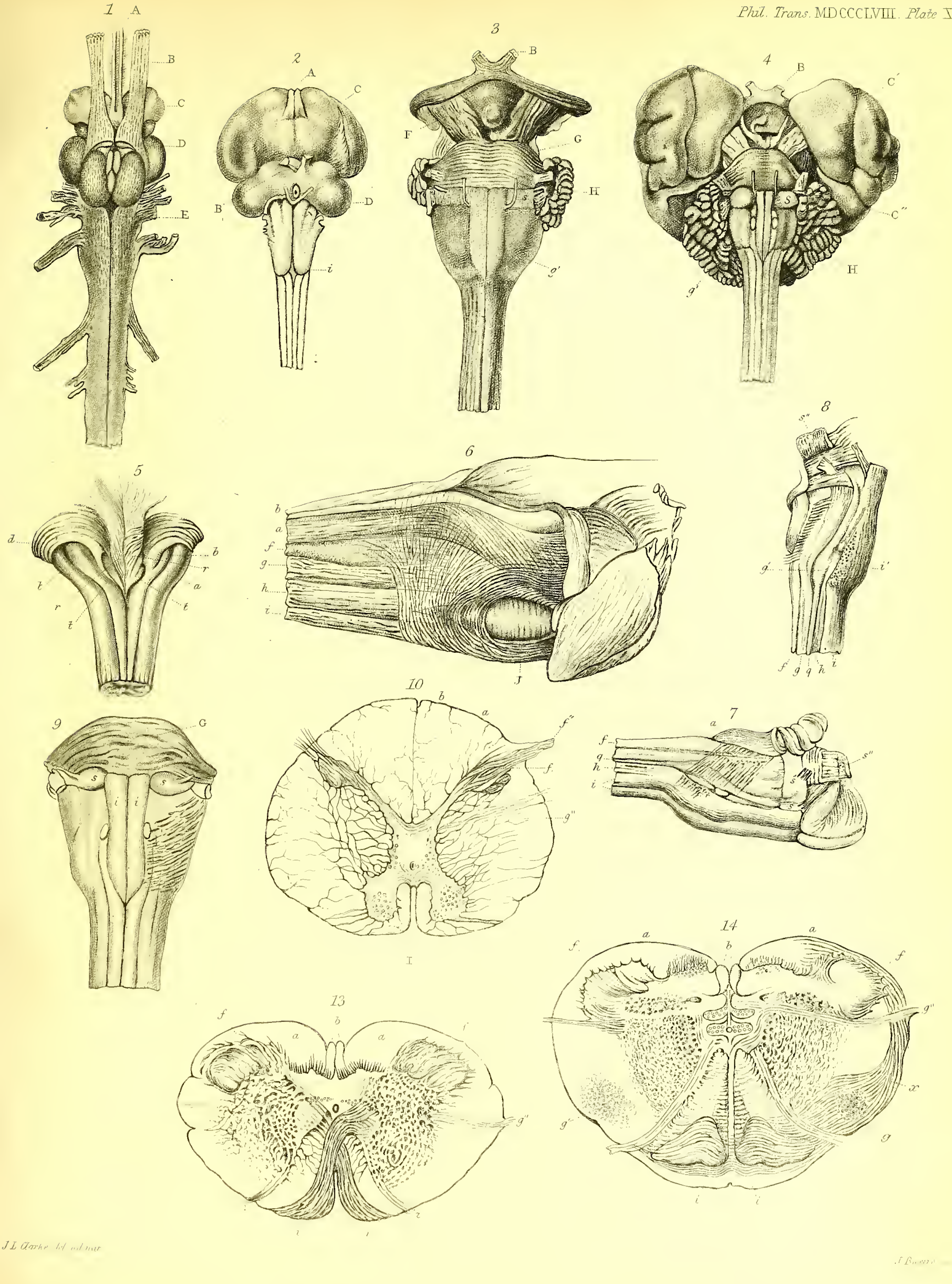
Fig. 35. Transverse section of the hypoglossal nucleus, t, and of part of the spinal-accessory nucleus, r, of the Sheep; z, hypoglossal nerve; g'', spinal-accessory nerve; C, central canal; R, the raphè.

Fig. 37. Cells of the human vagus ganglion magnified 420 diameters; some of them are pigmentary.

For explanation of fig. 36, see § 56, page 254, text.

Figs. 38, 39, 40. Left halves of the *medulla oblongata* of *Cercopithecus*, *Semnopithecus*, and the *Wanderoo* Monkey:—a, *anterior pyramid*; b, *olivary body*; c, *trapezium.*

Fig. 41. Left half of the *medulla oblongata* of *Ursus Syriacus*:—d, arciform fibres.



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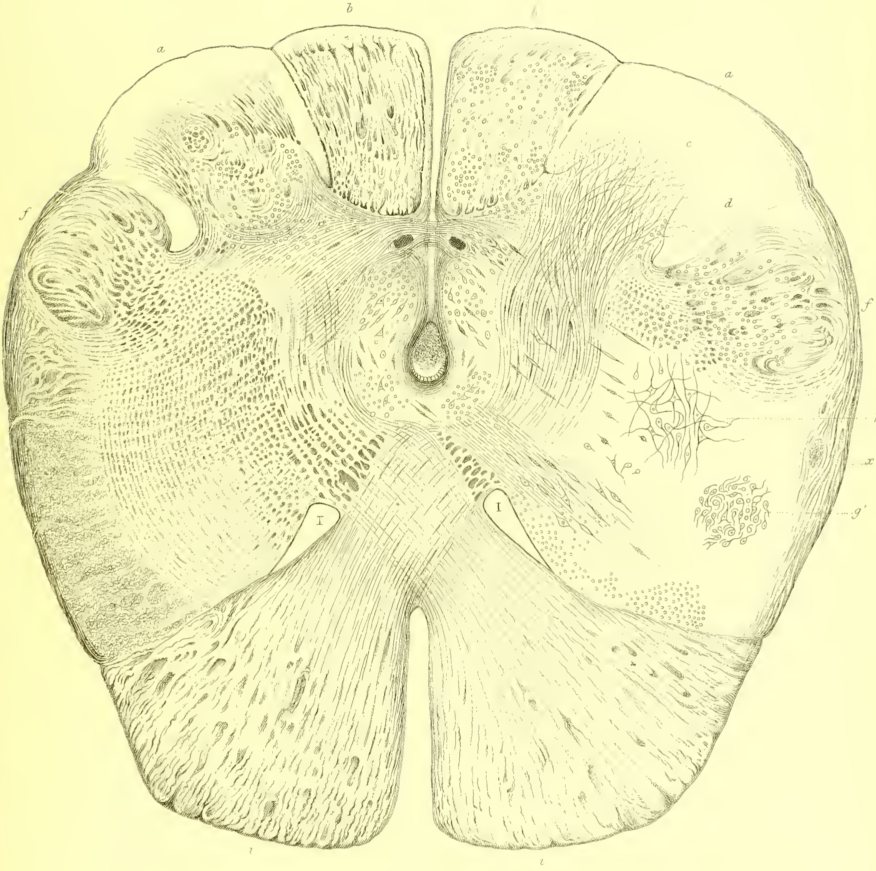

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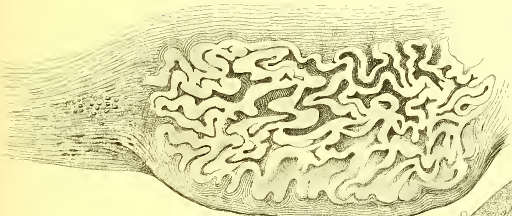

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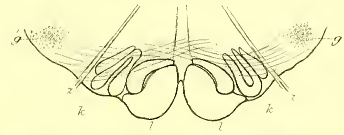

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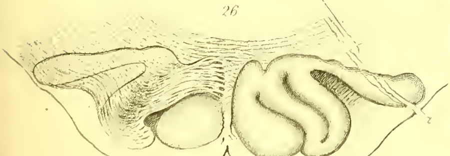

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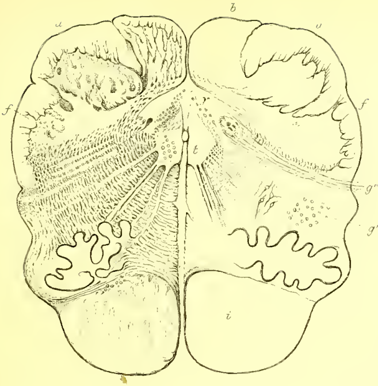

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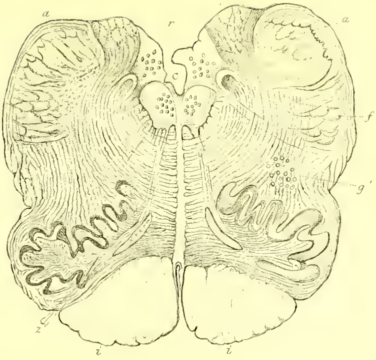

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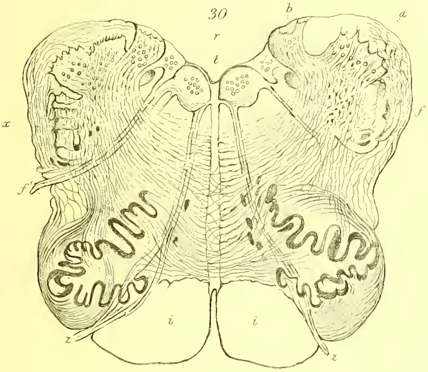

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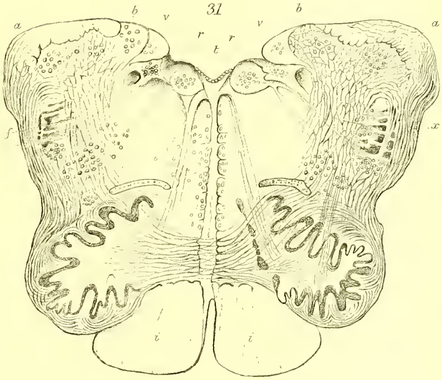

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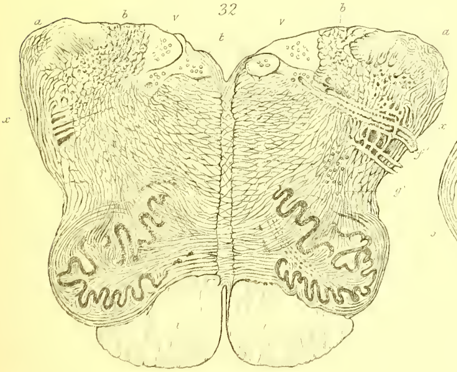

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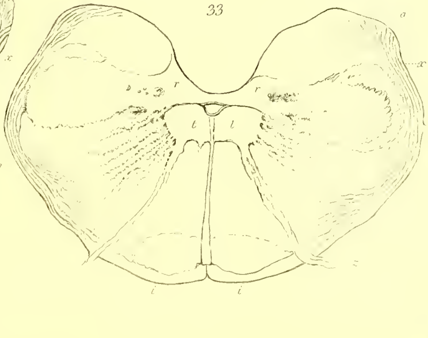
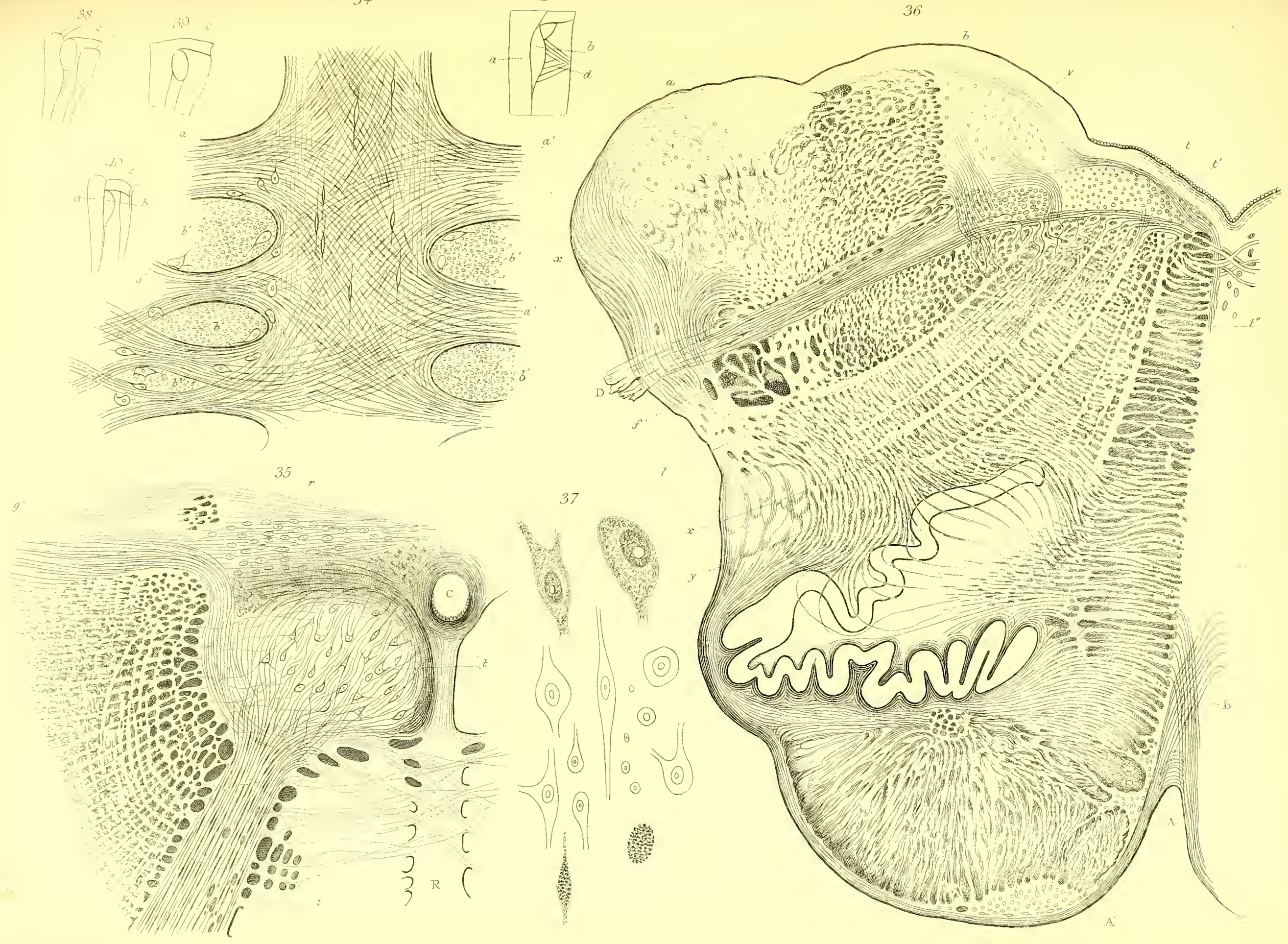


J. L. Clarke, del.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